Gustatory Sweating in the Submandibular Region Following Neck Dissection: A Case With Thermographic Evaluation and Review of the Literature

Hitoshi Yoshimura, DDS, PhD,* Takayoshi Tobita, DDS, PhD,† Masanobu Kumakiri, MD, PhD,‡ and Kazuo Sano, DDS, PhD§

Gustatory sweating is a fairly common complication after surgery or injury of the parotid gland.1 The pathogenesis is based on aberrant nerve regeneration between the parasympathetic fibers of the salivary glands and the sympathetic fibers of the cutaneous sweat glands or blood vessels.1 Inappropriate innervation leads to local cutaneous sweating and vasodilation during mastication.1 A similar condition has been reported in the cervical region after neck surgery, such as neck dissection,2–6 submandibular gland excision,7–19 and cervical lymphadenectomy,20 but the frequency of this condition is extremely rare. Since 1934, when the original report by Uprus et al7 appeared, only 26 cases have been reported in the English-language literature.

The authors present a case of gustatory sweating in the submandibular region after selective neck dissection. They investigated the severity of symptoms using thermography and found biphasic responses in gustatory sweating: cold spots from sweating and hot spots from vascular flushing. They also review previous cases and describe the etiology and treatment.

Report of Case

A 54-year-old woman was referred to the Department of Dentistry and Oral Surgery, University of Fukui Hospital, for the evaluation of a tongue ulcer in October 2009. The patient’s medical history disclosed the presence of biliary calculus. She smoked but did not drink alcohol. The physical examination showed an ulcer formation in the right lateral border of the tongue. The lesion was 9 × 9 mm and had developed over a period of 6 months. The laboratory data were within the normal range. Computed tomography and chest radiography were performed, and no cervical or lung metastases were found. The clinical diagnosis was tongue cancer (T1N0M0, stage I), and partial resection of the tongue was performed under intravenous sedation in November 2009. The surgical specimen was histologically diagnosed as well-differentiated squamous cell carcinoma. The surgical margin was free from tumor, and the postoperative course was uneventful.

Nine months later, the patient presented with swelling of the cervical lymph node. Computed tomographic examination showed an enlarged right submental lymph node, and metastasis was suspected. A right selective neck dissection (Level I–V) was performed under general anesthesia in August 2010. Drain tubes were retained in the submandibular, posterior cervical, and supraclavicular regions. The platysma and skin flap were sutured layer to layer. One of 21 lymph nodes in the specimen harbored metastatic carcinoma without evidence of extracapsular extension. Postoperative radiotherapy was not administered.

Fourteen months after the neck dissection and 23 months after the diagnosis, the patient complained of sweating in the submandibular region. Although she reported no pain, she wiped the sweating region with a handkerchief at every meal. The Minor starch-iodine test21 confirmed sweating in the right submandibular skin after 5 minutes’ mastication of a piece of chewing gum (Fig 1A). The gustatory sweating occurred in the upper portion of the horizontal neck scar, in an area measuring 5.5 × 3 cm, and did not extend below the horizontal neck scar (Fig 1B). Although the dark complexion of Asians makes it more difficult to identify the cutaneous vascular response,22 inspection showed skin flushing at the right buccal region after 5 minutes of masticatory stimulation (Fig 2A, B).

The authors tested for cutaneous thermal changes using medical thermography (Thermodracer TM3100, NEC-Sanei Co Ltd, Tokyo, Japan). An accommodation period of 10 minutes was required before scanning to allow the exposed area to approach thermal equilibrium at a constant room
temperature (27°C) and moisture (20%). At the beginning of the procedure, the patient was given a piece of chewing gum. Two and 5 minutes after masticatory stimulation, the thermal changes were recorded. The isothermal pattern on the dissected side was similar to that of the nondissected side before stimulation (Fig 3A); however, 2 minutes after the stimulation, cold areas were observed on the dissected site of the submandibular region. Five minutes after the stimulation, the cold areas were enlarged anterior to the submental region (Fig 3B). A hot area also was observed at the right buccal region after the stimulation. The isothermal pattern on the nondissected side showed no change before and after the stimulation. The temperature of the submandibular region decreased by 3.8°C (from 35.2°C to 31.4°C) on the dissected side, but no change was observed (from 35.0°C to 35.0°C) on the nondissected side after the stimulation. The isothermal pattern on the dissected side correlated positively with the areas of gustatory sweating and facial flushing after the stimulation.

There has been no recurrence or distant metastasis as of 21 months after the neck dissection, and the degree and extent of the gustatory sweating were improved after topical treatment with 20% (w/v) aluminum chloride hexahydrate (twice a day, 0.5ml in once).

**Discussion**

Facial gustatory sweating was first described by Duphenix as early as 1757 and later by Baillarger in 1853. In 1923, Frey described a case after an infected bullet wound and recorded that sweating occurred in the distribution of the auriculotemporal nerve. This condition was subsequently called the Frey syndrome or auriculotemporal syndrome and has become a fairly common complication after surgery or injury of the parotid gland. The pathogenesis is thought to involve aberrant auriculotemporal nerve regeneration. The resected parasympathetic fibers contact the sweat glands of the skin that are normally innervated by sympathetic fibers. As a consequence, acetylcholine, the neurotransmitter active in the sympathetic and parasympathetic nervous systems, triggers pathologic secretion from the sweat glands during mastication.

A similar condition has been reported after neck surgery, such as neck dissection, submandibular gland excision, and cervical lymphadenectomy, but the frequency of this condition is extremely low. The first case of gustatory sweating in the neck region was recorded in 1934 by Uprus et al and was related to the removal of the cervical gland 2 years previously. To the best of the authors’ knowledge, only 26 cases of gustatory sweating related to neck surgery have been reported in the English-language literature (Table 1). Gustatory sweating has been observed in surgically treated benign and malignant lesions. In most cases, the submandibular gland was excised, and the sweating area showed a striking predilection for the submandibular region, which accounted for 67% of cases (16/24; only 24 cases were described in...
In 13 patients with head and neck cancer, 12 patients did not receive neck radiotherapy. The interval from surgery to the onset of gustatory sweating generally ranged from 1 month to 2 years, although 1 case presented at 11 years after surgery.\(^3\)

The etiology remains incompletely understood, but similar to the gustatory sweating after parotidectomy, the theory of aberrant nerve regeneration is the accepted explanation.\(^3\) The chorda tympani carries taste fibers from the anterior two thirds of the tongue in addition to vasodilator fibers and parasympathetic secretomotor fibers to the submandibular gland through the lingual nerve. After removal of the submandibular gland, aberrant nerve regeneration is thought to occur from the sympathetic secretomotor fibers to the sweat glands and blood vessels of the overlying skin.\(^15\) This theory was verified by the finding that blocking the lingual nerve with local anesthesia resolved the condition,\(^3\,5\,7\,9\) whereas blocking the cervical sympathetic fibers that enter the submandibular ganglion did not abolish the condition.\(^2\,6\) Furthermore, gustatory sweating can occur even in a submandibular region reconstructed by a deltod-pectoral flap.\(^4\) Young\(^8\) called this symptom “chorda tympani syndrome” to distinguish it from the auriculotemporal syndrome. The typical interval of months to years from neural damage to the onset of clinical signs suggests that altered regeneration is the likely pathogenesis of gustatory sweating.

In the previous reports, although 45% (81/180 cases) of patients had noticed gustatory sweating after parotidectomy, gustatory sweating developed in only 1.5% (1/68 cases) of patients with submandibular exirpation and not at all (0/109 cases) after neck dissection.\(^16\) It is not clear why gustatory sweating is so rare after neck surgery. Surgery of the neck area certainly damages the integrity of the parasympathetic innervations, but regeneration does not elicit gustatory sweating in the same way as parotidectomy. There may be several reasons for this phenomenon: the submandibular gland lies deeper under the skin than the parotid; undermining the skin during surgical dissection is much less rigorous than in parotidectomy, which decreases the degree of sweat gland denervation; and the platysma may act as a natural barrier. This assumption has been substantiated by the finding that, after parotidectomy, “barriers” against parasympathetic fibers, such as the “superficial musculo-aponeurotic system” or others, were successfully introduced to prevent gustatory sweating. In addition, a “guiding structure,” such as the auriculotemporal nerve, is missing in the vicinity of the submandibular gland, making it much more difficult for resprouting parasympathetic fibers to find their way to the skin.\(^16\) In the present case, the submandibular gland was removed during the operation, and a drain tube was retained in the submandibular region, as was the digastric muscle, to prevent hematoma formation. It was speculated that negative pressure from the suction device decreased the distance between the lingual nerve and the skin, and, as a result, the chorda tympani fibers communicated anastomotically with superficial sweat glands beyond tissue barriers such as the platysma.

The diagnosis of gustatory sweating is based on subjective symptoms. Gustatory sweating has been reported to be present without being noticed by the patients.\(^16\) In a prospective analysis of gustatory sweating after parotidectomy,\(^26\) the Minor starch-iodine test was positive in 38% of patients at 3 months,
but none of these patients reported symptoms. Twelve months after surgery, the rate of patients who tested positive increased to 96%, but only 43% of patients were aware of the symptoms. The investigators pointed out the existence of a discrepancy between subjective symptoms (patient’s complaints) and objective data (Minor starch-iodine test). Therefore, this complication may occur more often than reported after neck surgery.

Recently, thermography has been introduced as a noninvasive, facile test that provides a qualitative visual analysis of the cutaneous capillary response in gustatory sweating. In the present case, thermography clearly showed biphasic responses of gustatory sweating and facial flushing; the gustatory sweating induced by masticatory stimulation appeared as cold spots, and the facial vasodilator reflex of gustatory sweating appeared as hot spots. Differences in skin temperature of more than 1.5°C are considered clinically significant. In the present patient, thermography showed a significant decrease in temperature of 3.8°C at the dissected site, and no change of temperature at the contralateral nondissected side after masticatory stimulation. Thus, thermography could detect the severity of symptoms of gustatory sweating directly and quantitatively in a way that corresponded to the changes in temperature. This modality could become useful for the diagnosis and evaluation of gustatory sweating.

The benefit of postoperative radiotherapy in head and neck squamous cell carcinoma progressively emerged in the 1970s and 1980s as a standard of care for patients at high risk of locoregional relapse after surgery. Prognostic indicators for locoregional relapse after surgery have been progressively identified and include the primary disease site, the surgical margins at the primary site, the presence of perineural invasion, the number and location of metastatic lymph nodes, and the presence of extracapsular rupture. Based on the clustering of these pathologic factors, a stratification of patients into 3 risk categories to reflect the need for postoperative irradiation has been proposed. Patients with extracapsular rupture or a combination of 2 or more risk factors have been identified as being at high risk of locoregional relapse; in contrast, in the absence of any risk
<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Age</th>
<th>Gender</th>
<th>Disease</th>
<th>Operation</th>
<th>SMGE</th>
<th>Neck Radiation</th>
<th>Symptom</th>
<th>Interval</th>
<th>Portion</th>
<th>Size (cm)</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uprus et al</td>
<td>1954</td>
<td>5</td>
<td>F</td>
<td>ND</td>
<td>Removal of cervical gland</td>
<td>Yes</td>
<td>ND</td>
<td>GS, FL</td>
<td>4 yr</td>
<td>Submentum</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Langenskiöld</td>
<td>1946</td>
<td>16</td>
<td>M</td>
<td>Tubercular cervical lymphatic glands</td>
<td>Cervical lymphadenectomy</td>
<td>ND</td>
<td>ND</td>
<td>GS</td>
<td>2 yr</td>
<td>Submentum</td>
<td>2 × 3</td>
<td>Excision of skin</td>
</tr>
<tr>
<td>Coldwater</td>
<td>1954</td>
<td>57</td>
<td>M</td>
<td>Lip cancer</td>
<td>RND, hemimandibulectomy</td>
<td>ND</td>
<td>No</td>
<td>GS</td>
<td>ND</td>
<td>Face</td>
<td>ND</td>
<td>Resection of auriculotemporal nerve</td>
</tr>
<tr>
<td>Young</td>
<td>1956</td>
<td>2</td>
<td>F</td>
<td>Enlarged tuberculous gland</td>
<td>SMGE, removal of cervical gland</td>
<td>Yes</td>
<td>ND</td>
<td>GS, FL</td>
<td>8 yr</td>
<td>Mentum, submentum</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Spiro and Martin</td>
<td>1967</td>
<td>24</td>
<td>M</td>
<td>Thyroid cancer</td>
<td>RND, hemithyroidectomy</td>
<td>ND</td>
<td>No</td>
<td>GS</td>
<td>11 yr</td>
<td>Mentum, above the clavicle</td>
<td>4, 5 × 9</td>
<td>ND</td>
</tr>
<tr>
<td>Spiro and Martin</td>
<td>1967</td>
<td>17</td>
<td>M</td>
<td>Thyroid cancer</td>
<td>RND, thyroid lobectomy</td>
<td>ND</td>
<td>Yes</td>
<td>GS</td>
<td>1 mo</td>
<td>Submandible</td>
<td>5</td>
<td>ND</td>
</tr>
<tr>
<td>Myers and Conley</td>
<td>1970</td>
<td>46</td>
<td>M</td>
<td>Thyroid cancer</td>
<td>RND, total thyroidectomy</td>
<td>No</td>
<td>No</td>
<td>GS</td>
<td>6 mo</td>
<td>Submandible</td>
<td>5 × 6</td>
<td>No treatment</td>
</tr>
<tr>
<td>Myers and Conley</td>
<td>1970</td>
<td>14</td>
<td>M</td>
<td>Malignant melanoma of cervical skin</td>
<td>RND, excision of skin</td>
<td>Yes</td>
<td>No</td>
<td>GS</td>
<td>1 mo</td>
<td>Submandible</td>
<td>4 × 6</td>
<td>No treatment</td>
</tr>
<tr>
<td>Myers and Conley</td>
<td>1970</td>
<td>69</td>
<td>M</td>
<td>Laryngeal cancer</td>
<td>RND, laryngectomy</td>
<td>Yes</td>
<td>No</td>
<td>GS</td>
<td>1 yr</td>
<td>Submandible</td>
<td>4 × 5</td>
<td>No treatment</td>
</tr>
<tr>
<td>Myers and Conley</td>
<td>1970</td>
<td>68</td>
<td>F</td>
<td>Malignant melanoma of upper gingiva</td>
<td>RND (bil), excision of alveolar process</td>
<td>No</td>
<td>No</td>
<td>GS</td>
<td>2.5 yr</td>
<td>Submandible (bil)</td>
<td>5 × 5, 6 × 5</td>
<td>No treatment</td>
</tr>
<tr>
<td>Myers and Conley</td>
<td>1970</td>
<td>58</td>
<td>F</td>
<td>Laryngeal cancer</td>
<td>RND, laryngectomy</td>
<td>Yes</td>
<td>No</td>
<td>GS</td>
<td>2 yr</td>
<td>Check, temple</td>
<td>3 × 3, 3 × 3</td>
<td>No treatment</td>
</tr>
<tr>
<td>Myers and Conley</td>
<td>1970</td>
<td>71</td>
<td>M</td>
<td>Cervical metastasis of tonsil cancer</td>
<td>RND, reconstruction by pedicle flap</td>
<td>ND</td>
<td>No</td>
<td>GS</td>
<td>5 yr</td>
<td>Submandible (deltoid-pectoral flap)</td>
<td>7 × 6</td>
<td>No treatment</td>
</tr>
<tr>
<td>Parkash and Ramakrishnan</td>
<td>1983</td>
<td>45</td>
<td>M</td>
<td>Tongue cancer (post interstitial radiation therapy)</td>
<td>RND</td>
<td>ND</td>
<td>No</td>
<td>GS, FL</td>
<td>1 yr</td>
<td>Submandible</td>
<td>ND</td>
<td>No treatment</td>
</tr>
<tr>
<td>Bailey and Pearce</td>
<td>1985</td>
<td>31</td>
<td>F</td>
<td>Pleomorphic adenoma of submandibular gland</td>
<td>SMGE</td>
<td>Yes</td>
<td>ND</td>
<td>GS, W</td>
<td>22 mo</td>
<td>Submandible</td>
<td>ND</td>
<td>Topical antiperspirant</td>
</tr>
<tr>
<td>Milton et al</td>
<td>1986</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>Undermining of skin</td>
</tr>
<tr>
<td>Earley and Stack</td>
<td>1988</td>
<td>15</td>
<td>M</td>
<td>Pleomorphic adenoma of submandibular gland</td>
<td>SMGE</td>
<td>Yes</td>
<td>ND</td>
<td>GS</td>
<td>7 yr</td>
<td>Mentum</td>
<td>ND</td>
<td>No treatment</td>
</tr>
<tr>
<td>Berini-Aytes and Gay-Escoda</td>
<td>1992</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>SMGE</td>
<td>Yes</td>
<td>ND</td>
<td>GS</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>No treatment</td>
</tr>
<tr>
<td>Haddick et al</td>
<td>1994</td>
<td>25</td>
<td>F</td>
<td>Sialolithiasis of submandibular gland</td>
<td>SMGE</td>
<td>Yes</td>
<td>ND</td>
<td>GS</td>
<td>4 yr</td>
<td>Submentum, submandible</td>
<td>ND</td>
<td>Topical antiperspirant</td>
</tr>
<tr>
<td>McEwen and Sanchez</td>
<td>1996</td>
<td>40</td>
<td>M</td>
<td>Pleomorphic adenoma of submandibular gland</td>
<td>SMGE</td>
<td>Yes</td>
<td>ND</td>
<td>GS, FL, W</td>
<td>ND</td>
<td>Face</td>
<td>ND</td>
<td>No treatment</td>
</tr>
<tr>
<td>Targue et al</td>
<td>1998</td>
<td>35</td>
<td>F</td>
<td>Sialolithiasis of submandibular gland</td>
<td>SMGE</td>
<td>Yes</td>
<td>ND</td>
<td>GS</td>
<td>1 yr</td>
<td>Submandible</td>
<td>ND</td>
<td>No treatment</td>
</tr>
<tr>
<td>Laskawai et al</td>
<td>1999</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>SMGE</td>
<td>Yes</td>
<td>ND</td>
<td>GS</td>
<td>1 mo</td>
<td>Submandible</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Persaud et al</td>
<td>2000</td>
<td>12</td>
<td>F</td>
<td>ND</td>
<td>SMGE</td>
<td>Yes</td>
<td>ND</td>
<td>GS</td>
<td>5 yr</td>
<td>Submandible</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Graham and Baldwin</td>
<td>2009</td>
<td>26</td>
<td>F</td>
<td>Tongue cancer</td>
<td>SND, glossectomy</td>
<td>Yes</td>
<td>No</td>
<td>GS, FL</td>
<td>8 mo</td>
<td>Submandible</td>
<td>ND</td>
<td>No treatment</td>
</tr>
<tr>
<td>Lee and Yoon</td>
<td>2010</td>
<td>41</td>
<td>M</td>
<td>Sialolithiasis of submandibular gland</td>
<td>SMGE</td>
<td>Yes</td>
<td>ND</td>
<td>GS, FL</td>
<td>1 yr</td>
<td>Submandible</td>
<td>ND</td>
<td>No treatment</td>
</tr>
<tr>
<td>Present case</td>
<td>2011</td>
<td>54</td>
<td>F</td>
<td>Tongue cancer</td>
<td>SND, glossectomy</td>
<td>Yes</td>
<td>No</td>
<td>GS, FL, W</td>
<td>14 m</td>
<td>Submandible</td>
<td>5.5 × 3</td>
<td>Topical antiperspirant</td>
</tr>
</tbody>
</table>

Abbreviations: bil, bilateral; F, female; FL, flushing; GS, gustatory sweating; M, male; ND, not described; RND, radical neck dissection; SMGE, submandibular gland excision; SND, selective neck dissection; W, warming.

*Age at surgery.
factor, the need for postoperative radiotherapy could not be shown.\textsuperscript{29,31} In the present case, postoperative radiotherapy was not performed because of the absence of these risk factors.

In radiotherapy of head and neck malignancies, radiation dermatitis is a common adverse effect. Early adverse effects include erythema, dry desquamation, and moist desquamation, and late adverse effects include pigmentation changes, telangiectasias, hair loss, atrophy, fibrosis, and ulceration.\textsuperscript{32} The sweating ability of irradiated skin continues to be suppressed for many years, and patients have dry skin in the region.\textsuperscript{33} Peripheral nerve injury and the impairment of nerve regeneration in the irradiated region have been reported in experimental and clinical studies.\textsuperscript{34–37} Indeed, radiotherapy can significantly decrease the incidence of gustatory sweating.\textsuperscript{38} After parotidectomy, only 2 of 14 patients (14\%) receiving radiotherapy complained of gustatory sweating, whereas 47 of 93 patients (51\%) who did not receive radiotherapy had the same complication.\textsuperscript{39} In the present review, 12 of 13 patients (92\%) with gustatory sweating after neck dissection did not receive neck radiotherapy. The absence of radiotherapy might be one reason that gustatory sweating was observed in these patients.

In general, the spontaneous regression of symptoms in a patient with gustatory sweating is most unlikely. The treatment depends on the severity of the symptoms. Various remedies such as topical antiperspirant application, topical anticholinergic drugs such as 20\% (w/v) aluminum chloride hexahydrate (twice a day, 0.5ml in once) and 3\% scopolamine hydrobromide cream, or even systemic anticholinergics such as 20\% (w/v) aluminum chloride hexahydrate (twice a day, 0.5ml in once) and 3\% scopolamine hydrobromide cream, or even systemic anticholinergics such as atropine have been tried, with varying levels of success and adverse reaction.\textsuperscript{15} Surgical solutions have included lingual nerve division, excision of the affected skin, interposition of a fascia-lata graft flap, superficial musculoaponeurotic system interposition, and dermis-fat grafts.\textsuperscript{15} Recently, the injection of botulinum toxin has produced good results and is considered a treatment option in patients with gustatory sweating.\textsuperscript{39,40} In the present case, the patient was treated with 20\% (w/v) aluminum chloride hexahydrate (twice a day, 0.5ml in once) and reported no difficulties with this condition. Although the use of radiotherapy is effective, the improvement of gustatory sweating alone is, of course, not justified as an indication for postoperative radiotherapy because of its side effects.\textsuperscript{40}

Gustatory sweating occurs very infrequently as a consequence of neck surgery compared with parotid gland surgery, and it is difficult to predict preoperatively which patients will develop gustatory sweating. In the case of submandibular gland excision, the surgery should be minimally invasive and treat the lingual nerve and submandibular ganglion securely. In the case of platysma resection, a surgical method should be selected that interposes a tissue barrier between the parasympathetic fibers of the lingual nerve and the sweat glands to block the path of nerve regeneration. Furthermore, the patient should be informed of the possibility of gustatory sweating appearing years after the surgical intervention, particularly in cases with no postoperative radiotherapy.

The present report may lead to further awareness of the symptom and aid in the management of this complication after neck surgery.

References